Durum wheat against climate change

G + GxE vs. E

ICARDA
Science for resilient livelihoods in dry areas

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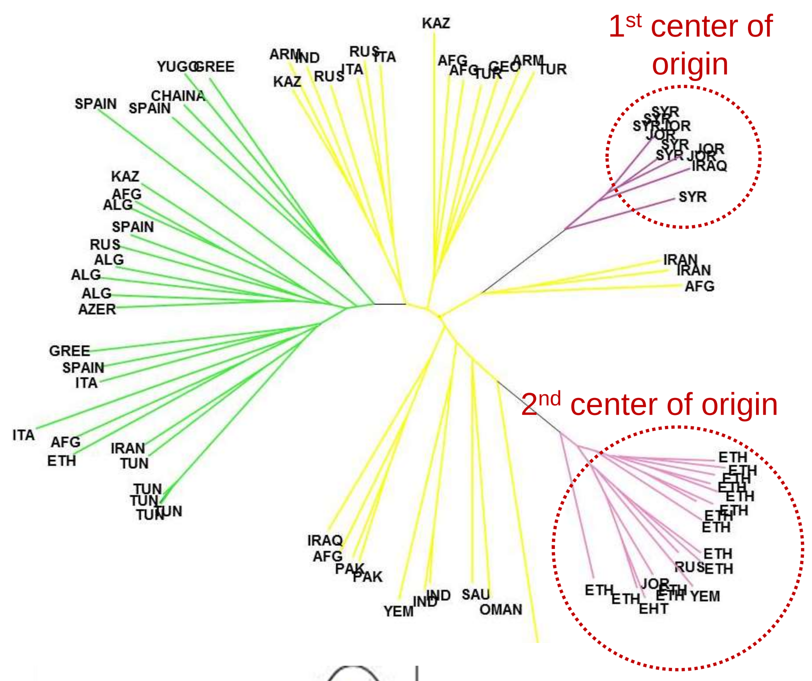
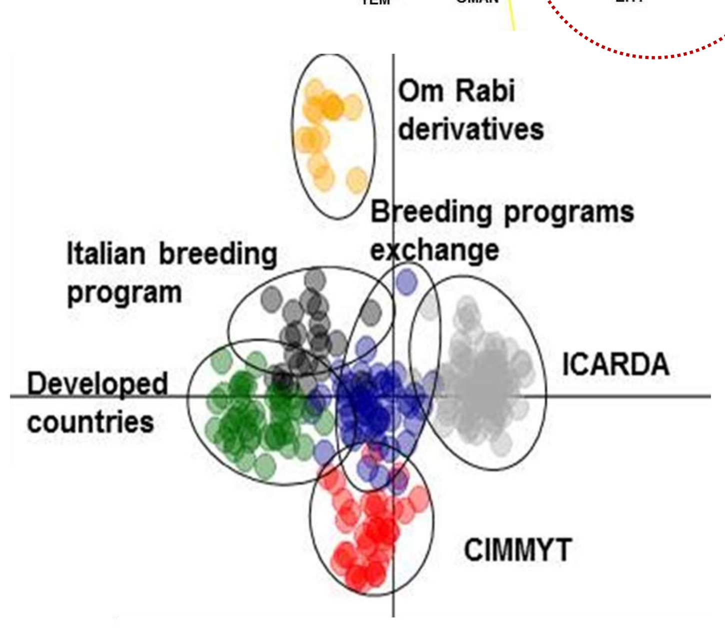
Maximizing genetic diversity for better adaptation

Genetic diversity within a global panel of durum wheat landraces and modern germplasm reveals the history of alleles exchange. Kabbaj et al. 2017. **Frontiers in Plant Sciences**, 8:1277.





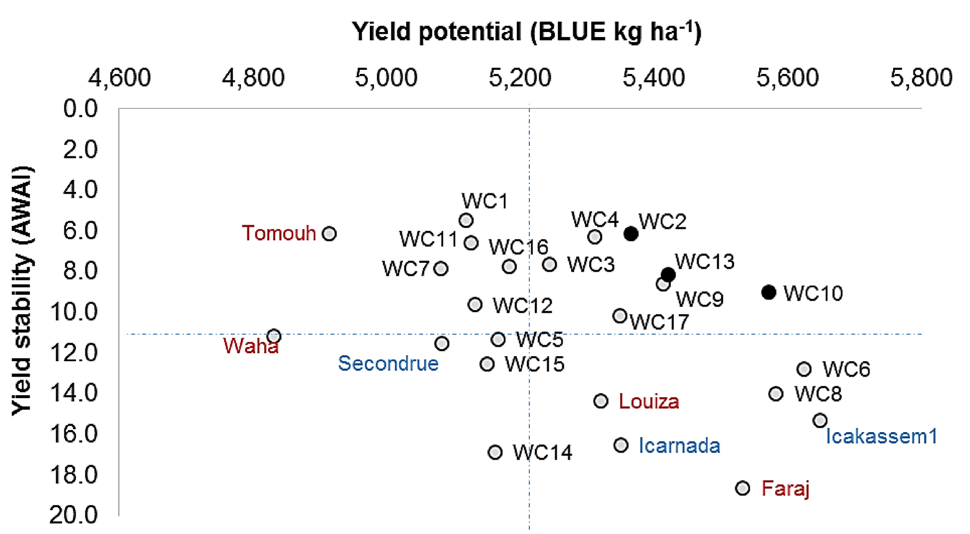
Cluster ID	N	Allelle segr. (%) Common	Rare
1. Middle East	11	0.13	0.00
2. *T. abyssinicum*	18	0.42	0.01
3. Mediterranean	26	0.65	0.06
4. C. and S. Asia	27	0.84	0.62
5. 'Om Rabi'	13	0.19	0.00
6. Italian	26	0.46	0.01
7. Exchange	58	0.58	0.04
8. Developed	30	0.43	0.01
9. ICARDA	119	0.51	0.03
10. CIMMY	42	0.44	0.21

Fig. 1 – Molecular and visual genetic diversity among landraces and modern lines as assessed with 8K SNPs on a panel of 370 global entries.

The clustering of different germplasm type based on their molecular similarities provided clear indications for breeding, such as the fact that CIMMYT and ICARDA germplasm maintain good diversity within and among each other. Also, landraces from Central and South Asia would represent ideal pools to seek useful rare alleles and diversity overall.

Effective use of wide crosses in breeding

Wide crosses of durum wheat reveal good disease resistance, yield stability, and industrial quality across Mediterranean sites. Zaim et al. 2017. **Field Crop Research**, 214:219-227.



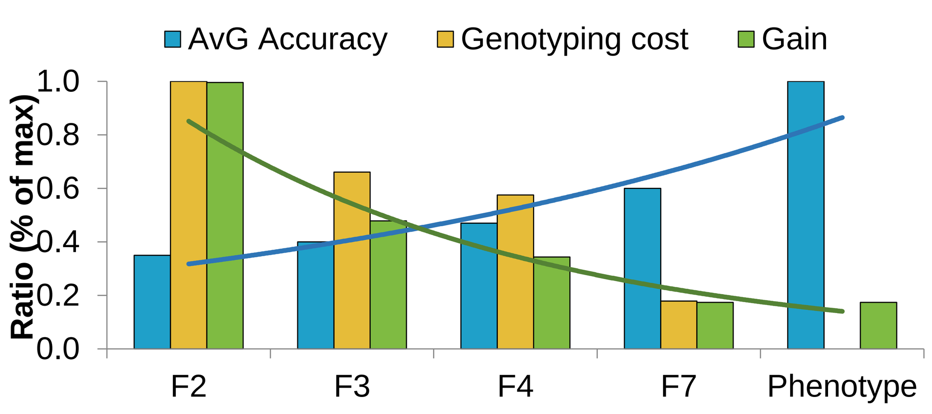
Germplasm	1,000-kernels (g) Avg.	Max	Protein (%) Avg.	Max	SDS test (ml) Avg.	Max	Yellow index (b*) Avg.	Max
Varieties	44.8 c	47.5 b	14.9 a	15.6 b	35.4 a	46.8 a	20.7 a	22.7 a
Elites	47.3 b	48.4 b	14.7 a	14.9 c	24.6 b	29.6 b	17.4 b	18.2 c
Wide cross	51.9 a	56.6 a	15.0 a	16.1 a	34.4 a	44.0 a	18.3 b	20.2 b
Grand Mean	50.1		14.9		33.3		18.6	
LSD	2.3		0.6		5.9		1.0	

Fig. 2 – Assessment of wide crosses (WC) against varieties (red) and elites (blue) across 12 North African stations to test yield potential (G) and yield stability (GxE).

Wide crosses obtained via top cross of ICARDA elites and primitive wheats (T. dicoccoides, T. Araraticum, and Ae. Speltoides) were field tested against 4 cultivars and 3 elites across 12 North African field sites, to reveal that WC2, 13, and 10 were superior to all other entries. Further, testing of industrial quality of grains from 6 sites confirmed that WC were also superior for grain size and protein content, matched the varieties for gluten strength, and was partially inferior for grain yellowness.

Genomic selection: a new frontier for breeding

Breeding schemes for the implementation of genomic selection in wheat. Bassi et al. 2016. **Plant Science**, 242:23.



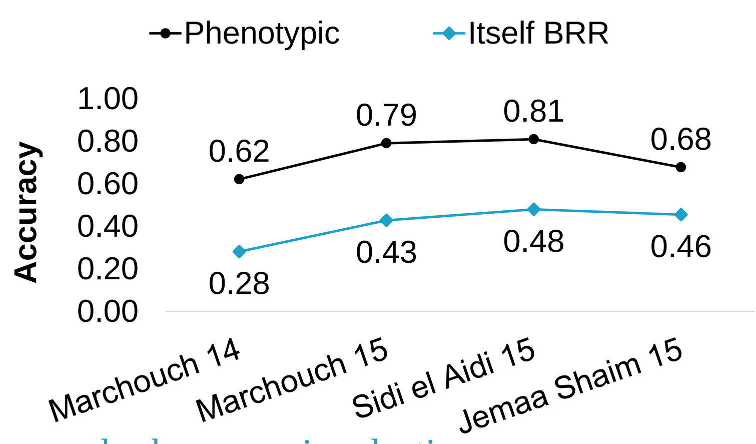
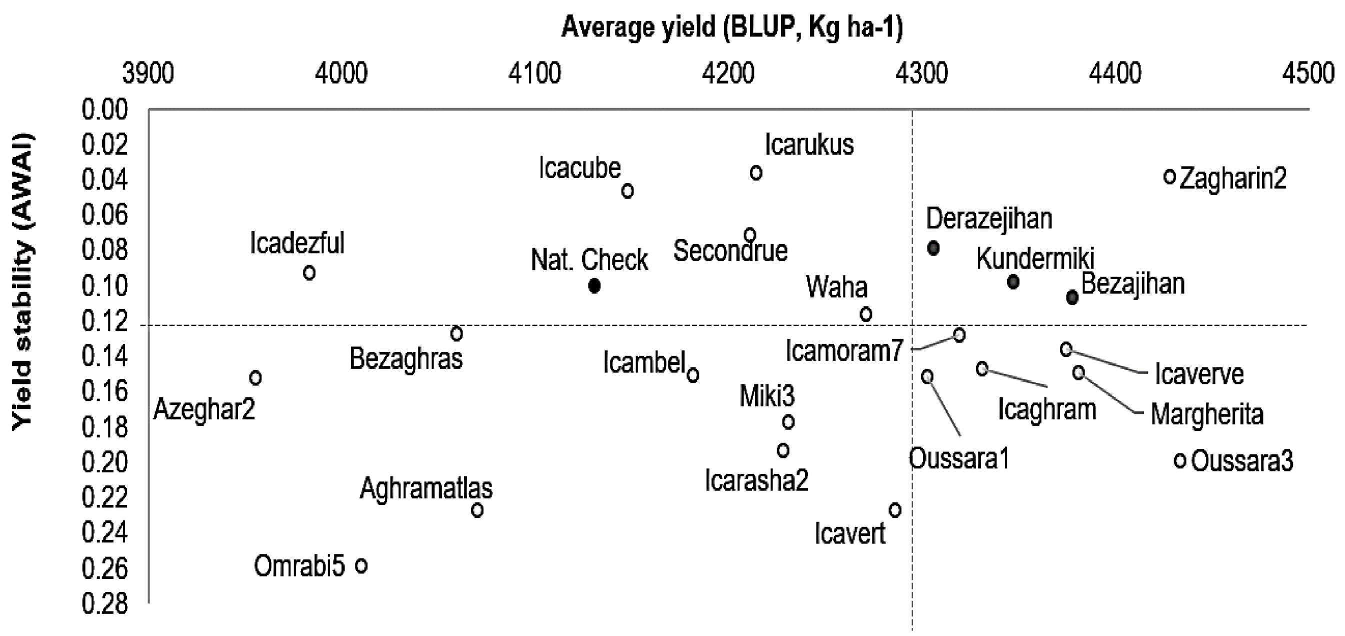


Fig. 3 – Accuracy vs. cost vs. gain of different recurrent selection cycles by genomic selection.

Performances of germplasm across sites

Adaptation and stability analysis of ICARDA durum wheat elites across 18 countries. Bassi & Sanchez-Garcia. **Crop Science** (cover), 57:2419.



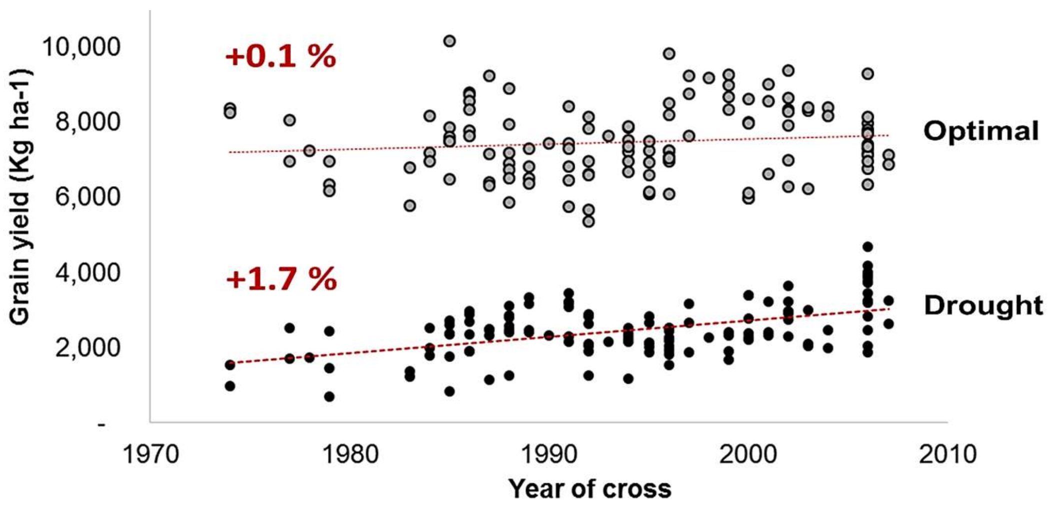
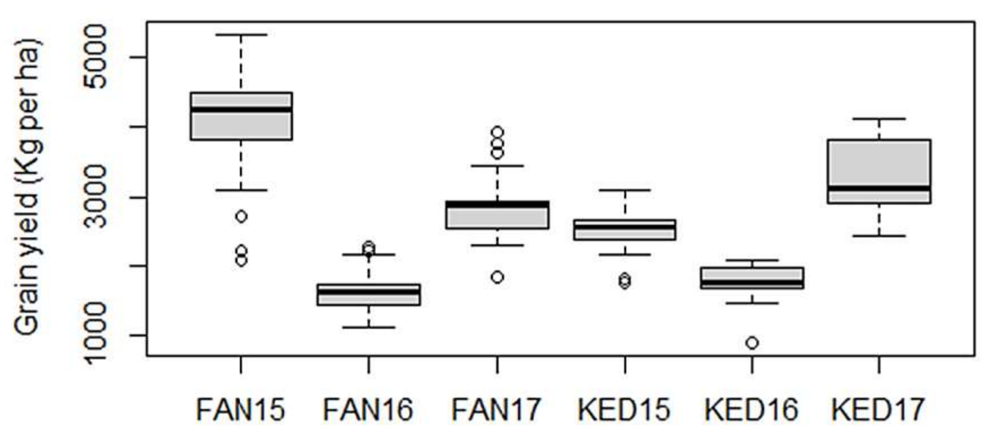


Fig. 4 – Selection for G (BLUP) and GxE (AWAI) components of grain yield of the ICARDA international nurseries assessed across 27 environments. Genetic gain study of an historical ICARDA set under optimal and drought conditions.

Performances of the international nursery IDYT38th were assessed on the basis of yield potential (G) and yield stability (GxE) to reveal 4 genotypes superior to all others (Zagharin 2, Derazejihan, Kundermiki, and Bezajihan). Also, am historical set of ICARDA was used to confirm a solid genetic gain of +1.7% per year under drought, and only 0.1% in favorable.

Adapting germplasm to heat and drought

Heat tolerance of durum wheat elites germplasm tested along the Senegal River. Sall et al. 2018. **Journal of Agricultural Science**, 10:217. *Root system architecture and its association with yield under different water regimes in durum wheat.* El Hassouni et al. 2018. **Crop Science**, under revision.



Environment	Type	Grain yield (Kg/ha)
Drought		
Kfardan	Shallow	1,658 a
	Deep	2,883 b
Marchouch	Shallow	1,785 a
	Deep	2,474 b
Favorable		
Terbol	Shallow	7,546 a
	Deep	7,287 a
Tessaout	Shallow	8,330 a
	Deep	8,417 a

Fig. 4 – Testing of heat tolerance at two sites in Senegal (FAN) and Mauritania (KED) for 3 years. Assessment of root angle at maturity and effect on grain yield under terminal drought.

Adaptation to extreme heat was obtained through improved capacity of maintaining flower fertility and larger number for grains per spikes. Dicoccoides derived lines resulted as the most adapted. The same type of lines were also capable of growing narrow deep roots that ensured 30-40% yield advantage under dry conditions and no disadvantage under favorable environments.

Conclusions

The phenotyping methodologies presented here, used in combination with the association mapping panel described, have unlocked the discovery of several key QTLs for drought and heat adaptation. These QTLs are now driving the crossing program. In addition, the markers are under conversion and validation to KASP and can then be used for MAS. Finally. GS can be applied to further accelerate the introgression.

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